Formation of Gas Giants

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We present results from three-dimensional global disk simulations of gas giant formation. Starting out from initial conditions with a disk in near-equilibrium, we let the disk (which has a central hole) cool until it becomes marginally gravitationally unstable. Axisymmetric modes are the first ones to become unstable, and as a result the innermost section of the disk first collapses into a dense ring, which eventually becomes unstable to non-axisymmetric perturbations. Because of the strong constraints from the Coriolis force, only a short section near a local density maximum of the perturbed ring can collapse to a protoplanet, and as a result the mass of the protoplanet is a small fraction of the disk mass. Once a dominating protoplanet has formed, the gravitational field associated with its orbital motions perturbs the remaining gas, prevents it from forming additional protoplanets, and assists in it's rapid accretion onto the central star by inducing spiral-shaped shocks. The end result is a single gas giant protoplanet in near-circular orbit, and a disk with an enlarged central hole.